

"9. They also travelled far into the interior of this island to obtain flint for the manufacture of their primitive stone implements.

"10. They did not possess implements of nephrite (greenstone)*.

"11. The polishing process of stone implements is of considerable age in New Zealand, as more finished tools have been found in such positions that their great antiquity cannot be doubted, and which is an additional proof of the long extinction of the Moas."

Thus Dr. Haast here appears to be absolute in every thing, and it is with an appearance of absolute certainty that he asserts or denies facts. But we shall see that he has himself been obliged to go back over some of these propositions and to recognize that some of them are not well founded. Nevertheless the general convictions of the learned geologist have not been shaken on this account, and we shall have to inquire whether this persistence is justified.

[To be continued.]

XIX.—*On the Presence of Eyes and other Sense-Organs in the Shells of the Chitonidæ.* By H. N. MOSELEY, M.A., F.R.S., Linacre Professor of Human and Comparative Anatomy in the University of Oxford.

ON examining a specimen of *Schizochiton incisus*, preserved in spirit amongst a number of other animals dredged by Captain W. Chimmo, R.N., in the Sulu Sea, in H.M.S. 'Nassau' in 1871, and by him presented to the Anatomical Department of the Oxford University Museum, I was astonished to remark on the shells certain minute, highly refracting, rounded bodies arranged in rows symmetrically; they struck me at once as resembling eyes, and further examination proved that such is really their nature. On searching for eyes on the shells of other Chitonidæ I found them present in the majority of the genera, differing, however, in each genus more or less in structure and arrangement.

The eyes in the Chitonidæ are entirely restricted to the outer surface of the shells on their exposed areas (tegumentum), not extending at all on to the laminae of insertion (articula-

* It is with this stone, often called *jade*, that the Maoris fabricated their stone clubs, *haches*, and various ornaments. It was of great value in their eyes, and often plays a part in their legends. Upon this point I have given some details, borrowed from Sir George Grey, in a book entitled 'Les Polynésiens et leurs migrations.'

mentum), and never being present on the girdle or zona, which is occupied, as is well known, by various calcareous structures, some of which have been carefully investigated by Reincke*.

In the case of all the intermediate shells the eyes are confined to the *areae laterales*, or to the line of demarcation between the *areae laterales* and the *area ventralis*, which latter is usually entirely devoid of them.

The eyes, which are mostly circular in outline as seen on the shell-surfaces, measure about $\frac{1}{175}$ of an inch in diameter in *Schizochiton incisus*, $\frac{1}{350}$ of an inch in *Acanthopleura spinigera*, and in *Corephium aculeatum* (in which they are oval in outline) $\frac{1}{300}$ of an inch by about $\frac{1}{400}$. In *Enoplochiton* they are smaller still and only with difficulty seen at all.

The eyes appear, when viewed by reflected light with a low power of the microscope, as highly refracting, convex, circular spots, looking as if made of glass or crystal; they are surrounded and set off by a narrow zone of dark pigment, which is the margin of the choroid seen through the superficial shell-substance. In the centre of each convex spot is a smaller circular area, somewhat darker, caused by the outline of the iris, but showing a brilliant speck of totally reflected light, due to the lens.

The entire substance of the tegmentum in the Chitonidæ is traversed by a series of branching canals, which are occupied in the living condition of the animal by corresponding ramifications of soft tissues, accompanied by abundance of nerves. The nerves and strands of other soft tissue enter the substance of the tegmentum along the line of junction of its margin with the upper surface of the articulamentum. A narrow area, perforated all over by pores, so as to have a sieve-like appearance, here intervenes between the two components of the shells, and in some shells the actual margin of the tegmentum itself is perforated. In the case of the intermediate shells, in most genera there are a pair of slits (*incisuræ laterales*), one on either side, in the lateral lamina of insertion; these slits lead to two narrow tracts in the deeper substance of the shell, which follow the line of separation between the *area centralis* and the *areae laterales* of the tegmentum. These narrow tracts are permeated by numerous longitudinal canals which lodge each a specially large stem of soft tissue and nerves, which ramifies in the substance of the tegmentum. Corresponding with this tract on the under surface of the shell are a series of minute openings leading into it, through which further strands of soft tissue, possibly mostly nervous, pass

* "Beiträge zur Bildungsgeschichte der Stacheln &c. im Mantelrande der Chitonen," Zeitschr. für wiss. Zool. Bd. xvii. S. 305.

from the surface of the shell-bed into the shell, to give the general network of soft tissue. In the anterior and posterior shells there are usually a considerable number of such marginal slits, each with a corresponding tubular tract and ramifying strands of soft tissues.

The network of soft tissues contained in the canals within the tegmentum ramifies towards the shell-surface and terminates there either in eyes or in peculiar elongate bodies, which, apparently, are organs of touch. These latter are long, somewhat sausage-shaped bodies, which terminate at their free extremity in dicebox-shaped plugs of transparent tissue, which show a somewhat complicated structure.

The tegmenta of the shells of most Chitonidæ are perforated at the surface by circular apertures or pores of two sizes, arranged in more or less definite patterns with regard to one another and sometimes with regard to the eyes also.

The end plugs of the sense-organs above described lie in these larger pores. From the sides of the sausage-shaped sense-organs are given off more or less numerous fine strings of soft tissue, which, diverging, pass to the smaller pores above described and there terminate in very small plugs, just like those of the larger similar organs, but less complex in structure.

The eyes are evidently to be regarded as having arisen as modifications of some of the organs of touch above described. They are connected with the same network as terminal organs of its ramifications in the same manner, and have points of resemblance to them which are convincing as to the homogeneity of the two. The soft structures of each eye lie in a more or less pear-shaped chamber excavated in the substance of the tegmentum. The stalk of the pear, which forms the canal for the passage of the optic nerve, is directed always towards the free margin of the tegmentum, whence the nerve reaches it. One side of the bulb of the pear is closely applied to the outer surface of the tegmentum, and here its wall is pierced by a circular aperture, which is covered by the cornea. The cornea is calcareous; it resists the action of strong boiling caustic alkalies, but collapses at once when treated with acid. Probably some soft tissue is present in its substance, but I have been unable as yet to find it.

The cornea in sections shows itself to be formed of a series of concentric lamellæ; its substance is continuous with the general calcareous substance of the tegmentum at its margins.

The pear-shaped cavity of the eye formed by the shell-substance is lined by a dark brown pigmented choroid membrane of a stiff and apparently somewhat chitinous texture. This membrane exactly follows the shape of the cavity, but

by projecting beyond the margin of the cornea all round forms an iris of less diameter than the latter.

A perfectly transparent, hyaline, strongly biconvex lens is fitted in behind the iris-aperture. The lens is composed of soft tissue, and dissolves in strong acetic acid, gradually but completely, showing a fibrous structure in the process.

The optic nerve at some distance from the eye is a compact strand; but within the very long tube continuous with the choroid—the narrow part of the pear—its numerous fine fibres are much separated from one another and loose. The retina is formed on the type of that of *Helix*, and not, as might have been expected, that of the dorsal eyes of *Oncidium*. It is not perforated by the optic nerve, but is composed of a single layer of very short but extremely distinct and well-defined rods, with their extremities directed towards the light. Beneath them is a layer or several layers of nuclei amongst the ultimate ramifications of the nerve.

Not all the fibres of the nerve entering the eye-cavity proceed to the retina. A large number of the peripherally-placed fibres pass outside the retina all round, and, perforating the choroid at its outer margin, end at the surface of the shell, all round the area occupied by the cornea. They terminate in small plugs of tissue, corresponding to those minor organs of touch universally distributed over the shell in the smaller pores already described—being, in fact, exactly similar and identical structures with these. They apparently form a sensitive zone round each eye, and they arise from the optic nerve just as do the other minor sense-organs from the nerves of the larger organs of touch. The choroid sacs of the eye show a curious open fold or gutter leading from the bulb superficially along the stalk of the pear, recalling curiously the choroid fissure.

In some genera of the Chitonidæ eyes are entirely absent. This is the case with the genus *Chiton*. The shell in *Chiton* is perforated; the usual small and large pores and the small and large touch-organs are present, but I have as yet found no trace of eyes. I have examined especially *C. magnificus* and *C. marmoratus*. In *Molpalia*, *Maugina*, *Lorica*, and *Ischnochiton* there appear to be also no eyes so far as a cursory examination has yielded evidence to me.

The arrangement and forms of the eyes vary much in different genera, and will probably prove of great value in classification, which has hitherto proved so difficult a problem.

The genus *Schizochiton* is distinguished by having the mantle deeply notched posteriorly in correspondence with a deep median notch in the posterior shell. In *Schizochiton incisus* the eyes are restricted to single rows traversing the

lines which in the intermediate shells separate the central from the lateral areas, and which correspond in position with the marginal slits and the courses of the principal nerves. There are six rows of eyes on the anterior shell, two on each of the intermediate shells, and six on the posterior shell—twenty-four rows altogether, with an average of about fifteen eyes in each, or in all 360 eyes. In the specimen examined all the rows except one have the eyes arranged in a single straight row at regular intervals, but at the base of one row there are, as an exception, two eyes side by side. There are also a very few irregularly scattered eyes on the lateral area, showing that the condition here existing is probably derived from one in which the eyes were more ancestrally diffused.

In *Acanthopleura spiniger* the eyes are irregularly scattered around the bases of the tubercles with which the surface of the tegmentum is covered, and are confined, in the specimens I have examined, to the region of the margins of the shell adjoining the mantle. The eyes in this species seem to be very liable to be broken or to flake off, in consequence of the decay of the surface-laminæ of the tegmentum. Hence those remaining on old specimens are those probably most recently formed by the mantle at the margin of the tegmentum. In decalcified tegmenta of some species I have seen eyes thus apparently in process of formation and not yet completed. In some specimens to be referred apparently to this species I have been unable to find any eyes at all. It will be necessary to examine a series of specimens of various ages to discover whether the eyes are originally more widely extended over the shell-surface or always marginal only in this species.

In a large *Corephium aculeatum*, the exposed shells of which were densely covered by a green alga, immense numbers of eyes were found when the alga was scrubbed off, and at the newest margin of the shell not yet encroached upon by the plant. The eyes are very small and their corneas are oval in outline, the long axis of the oval being directed vertically parallel with the height of the shell. The two kinds of pores are arranged in vertical parallel lines with great regularity, the large pores occurring at intervals in the lines of smaller pores. The eyes are never placed on the tubercles, with rows of which the shell is covered, and which are possibly contrivances for protecting the eyes from being rubbed and destroyed.

The eyes are present in enormous numbers. I estimate the numbers present on the anterior shell alone at 3000, counting only the younger ones, which are in good condition, near the free margin of the tegmentum, and not the older eyes, more or less destroyed by the boring of the shell by algæ and animals on the rest of the area. On the remaining shells, at

a moderate estimate, reckoning, as before, only the eyes in tolerable condition, there must be at least 8500 eyes.

In *Tonicia marmorata* the eyes have the peculiarity of being sunk in little pit-like depressions of the shell-surface. This, no doubt, is a contrivance for preventing them from being worn off, and the result is that they are all retained complete in large old specimens. They are arranged in single, straight, radiating rows on the anterior and posterior shell, disposed with considerable symmetry. There are thirty-four such lines on the anterior shell in one specimen, containing about eighteen eyes each. On each lateral area of the intermediate shells there are from two to four similar rows of eyes, with a few eyes grouped irregularly also. In some forms placed in the British-Museum collection as species of *Tonicia*, there are no eyes present; these possibly will be found to require to be placed in a separate genus.

In *Ornithochiton* the eyes are not sunk so deeply in pits, but are disposed somewhat as in *Tonicia*, though the rows are not so regular. In *Chitonellus* there are no eyes and but a scanty supply of organs of touch.

I have been unable to trace the nerves supplying the shells and eyes directly to their source, although I have no doubt that they proceed from the parietal (branchial) nerve, from which I have traced numerous offsets proceeding in the required direction.

I have searched in vain for any similar eyes in the shells of *Patella* and allied genera. The tegmentary part of the shell of the Chitonidæ appears to be something *sui generis*, entirely unrepresented in other Mollusca. Its principal function seems to be to act as a secure protection to a most extensive and complicated sensory apparatus, which in the Chitonidæ takes the place of the ordinary organs of vision and touch present in other Odontophora, and fully accounts physiologically for the absence of these in the group. In some respects the arrangement of the hard and soft parts curiously resembles that existing in the Brachiopoda.

It is most remarkable that these eyes should have been missed hitherto by all writers on the shells of the Chitonidæ. The fact is due, no doubt, to their minuteness and to the fact that they are not very easily seen with a powerful lens in the dried condition of the shell in most instances. In order that they may be made most conspicuous the dried shell should be wetted with spirit, and a lens as powerful as Hartnack's no. 4 objective be used.

Dr. W. B. Carpenter* observed the perforate structure of the tegmentum in *Chiton*, but did not apparently investigate

* 'Cyclopædia of Anatomy and Physiology,' article "Shell," p. 565.

the contained soft structures. He writes, "In *Chiton* the external layer, which seems to be of a delicate fibrous texture, but which is of extreme density, is perforated by large canals, which pass down obliquely into its substance, without penetrating, however, as far as the middle layer."

My father-in-law, Dr. Gwyn Jeffreys, has pointed out to me that Costa* figures what are evidently the eyes on one of the intermediate shells of a very small species of *Chiton* (*Tonicia*) *rubicundus*. They are figured as mere black dots and referred to as fine punctuations, but their arrangement is correctly shown.

The late Dr. Gray†, in his well-known paper on the structure of the *Chitons*, wrote:—"The greater number of species have a part of the valve which is not covered by the mantle, but exposed. This exposed part consists of a perfectly distinct external coat, peculiar, I believe, to the shells of this family. The outer coat of these valves is separated from the lower or normal portion by a small space, filled by a cellular calcareous deposit, which is easily seen in a section of the valves."

I have prepared drawings illustrating the arrangement and structure of the eyes and other sense-organs in the shell in various genera of Chitonidæ, and hope to publish them with a more complete account of my results in the coming winter.

I beg to express my best thanks to Dr. Günther for giving me every facility in making use of the British-Museum collection. Dr. Woodward kindly went over the fossil *Chitons* in the Palæontological Department with me, but we could detect no traces of eyes in any of them. This is remarkable, since the ancient forms of the group appear to be allied to *Schizochiton*.

MISCELLANEOUS.

On the Submaxillary in Masticating Insects.

By M. J. CHATIN.

THE maxilla in masticating insects is supported by a basal piece the functional importance of which cannot be disputed, but which possesses a still greater interest from the point of view of the morphology of the parts of the mouth and even of the appendicular organs considered generally. Nevertheless it has hardly been even mentioned by a few writers, among whom we must cite Kirby and Spence, who gave it the name of the *cardo* (hinge), a term happily enough representing its mode of articulation; Brullé gave it the name of *submaxillary*, which I here retain, so as not to introduce any neologism into an exposition already full of details.

* 'Fauna di Napoli: Animali molli, Chitone,' taf. iii. fig. 1, e.

† J. E. Gray, "On the Structure of the *Chitons*." Phil. Trans. 1848.